Elk Valley Water Quality Plan
Annex K. 2
Evaluation of Element Concentrations in Fish Tissues, Sediment, and Surface Water Collected from Lake Koocanusa

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## Technical Memorandum

To: Teck Coal Limited<br>From: David DeForest<br>Subject: Evaluation of Element Concentrations in Fish Tissues, Sediment, and Surface Water Collected from Lake Koocanusa

Date: July 16, 2014

This memorandum reviews element concentrations in fish tissues, sediment, and surface water from Lake Koocanusa in British Columbia and Montana. Trace element concentrations were compared to existing guidelines and toxicity reference values (TRVs) to evaluate current baseline data from the reservoir and the potential for trace elements to adversely affect aquatic biota.

## 1 TISSUE

### 1.1 Data

Fish tissue samples were collected predominantly between 2007 and 2013 in Canadian portions of Lake Koocanusa, and in 2008 and 2013 in US portions of the reservoir. Fish species sampled were bull trout (BT), burbot (BBT), kokanee (KKN), longnose sucker (LNS), largescale sucker (LSS), mountain whitefish (MWF), northern pikeminnow (NPM), peamouth chub (PMC), rainbow trout (RBT), and westslope cutthroat trout (WCT). This evaluation focused on selenium and mercury concentrations in fish, as they were the primary constituents analysed.

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### 1.2 Evaluation of Selenium Concentrations in Fish

Four lines of evidence were used to evaluate selenium concentrations measured in fish tissues:
(1) Comparison to British Columbia Ministry of Environment (BCMOE) guidelines of $4 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ for whole body (WB)/muscle and $11 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ for ovaries/eggs.
(2) Comparison to draft United States Environmental Protection Agency (USEPA) criteria of $8.1 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ for $\mathrm{WB} /$ muscle $^{1}$ and $15.2 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ for ovaries/eggs.
(3) For species sampled in both exposed portions of Lake Koocanusa and non-mine influenced areas, comparison to selenium concentrations in non-mine influencedarea fish on a species-specific basis ${ }^{2}$.
(4) A probabilistic assessment of selenium risks, based on the concentration-response curve for the most sensitive species tested to date (brown trout; which is non-native and does not occur in Lake Koocanusa).

### 1.2.1 Comparison to BCMOE Guidelines

Selenium concentrations in Lake Koocanusa WB/muscle samples exceeded the BCMOE guideline of $4 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ at a frequency $14 \%$, while non-mine influenced-area fish $\mathrm{WB} /$ muscle samples exceeded the BCMOE guideline at a frequency of $44 \%$ (Table 1). ${ }^{3}$ Likewise, selenium concentrations in Lake Koocanusa fish-ovary samples exceeded the BCMOE guideline of $11 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ at a frequency of $6 \%$, while non-mine influenced-area fish-ovary samples exceeded the guideline at a frequency of $24 \%$ (Table 2).

The BCMOE guidelines of $4 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ for $\mathrm{WB} / \mathrm{muscle}$ and $11 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ for ovaries/eggs are very conservative, particularly for the Elk Valley region, as exemplified by the relatively high frequency of exceedances by non-mine influenced-area fish. Both of these fishtissue selenium guidelines include an uncertainty factor (UF) of 2 (BCMOE 2014), which is applied to an already conservative, but not unreasonable, interpretation of the data.

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### 1.2.2 Comparison to Draft USEPA 2014 Criteria

The draft USEPA selenium criteria currently out for review are $8.1 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ for WB fish tissue and $15.2 \mathrm{mg} / \mathrm{kg}$ dw for ovaries/eggs. Two primary differences between the USEPA draft criteria and BCMOE guidelines are that the USEPA draft criteria are based on a species sensitivity distribution (SSD) approach, and that they do not consider application of generic UFs. These draft criteria are still conservative, as they are intended to ensure nation-wide protection, and they are based on the $5^{\text {th }}$ percentile of low-effect concentrations (e.g., EC10s) for all fish species tested.

Selenium concentrations in excess of the 2014 draft USEPA criteria in Lake Koocanusa fish for $\mathrm{WB} /$ muscle tissue was $0.2 \%$, and $2 \%$ in samples collected from non-mine influenced areas (Table 1). For ovaries, the frequency of samples exceeding the criteria was $1 \%$ for within Lake Koocanusa and $8 \%$ for non-mine influenced-area samples (Table 2). Given these results, it is clear that the UF of 2 that was used to develop the BCMOE selenium guidelines has a substantial influence on interpreting fish-tissue selenium concentrations in Lake Koocanusa and non-mine influenced areas.

### 1.2.3 Comparison to Non-mine Influenced Area Concentrations

As noted in Section 1.1, selenium concentrations were measured in several different fish species in both Lake Koocanusa and non-mine influenced areas. Because selenium bioaccumulation potential varies among species, the purpose of this evaluation was to compare selenium concentrations measured in Lake Koocanusa and non-mine influenced areas on a species-specific basis. There were six species for which these comparisons could be made for WB/muscle tissue, and five species for which this comparison could be made for fish ovaries. A comparison of mean, minimum, and maximum selenium concentrations is provided in Figure 1, with more detailed plots provided in Attachment A and B for WB/muscle and ovaries, respectively.

### 1.2.4 Probabilistic Assessment of Selenium Risks to Individual Fish

As a final line of evidence, the cumulative probability distribution of ovary selenium concentrations in samples from Lake Koocanusa was integrated with the concentrationresponse curve for brown trout, which serves as a surrogate for sensitive species, to estimate mean risk probability. Given that ovary selenium concentrations in mountain whitefish were

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high in both exposed and non-mine influenced-area samples, this species was excluded from the analysis. Considering all ovary selenium data pooled across fish species, the calculated risk, based on the conservative brown trout concentration-response curve, was $1.4 \%$. When the data for peamouth chub (PMC) were considered separately, as ovary selenium concentrations are greater in this species compared to others, the calculated risk was $1.9 \%$ (predicted risks for other individual fish species would be less than this). Accordingly, selenium risks based on the current data are predicted to be negligible to all fish species.

### 1.3 Evaluation of Mercury Concentrations in Fish

Mercury in fish tissues was evaluated by comparing concentrations to a BCMOE guideline of $0.033 \mathrm{mg} / \mathrm{kg}$ ww for birds ${ }^{4}$, and a dietary TRV of $0.04 \mathrm{mg} / \mathrm{kg} \mathrm{ww}$ for a piscivorous fish (Depew et al. 2012). It was assumed that all mercury measured in fish tissue was present as methylmercury ( MeHg ).

The BCMOE guideline of $0.033 \mathrm{mg} / \mathrm{kg}$ ww was adopted from the Canadian Council of Ministers of the Environment (CCME 2000). The guideline is based on the most-sensitive, avian, lowest-observed-adverse-effects level (LOAEL) identified by CCME 2000, which was 0.075 mg per kg of body weight (BW) per day ( $\mathrm{mg} / \mathrm{kg} / \mathrm{d}$ ) for mallards. This LOAEL was divided by 5.6 to estimate a no-observed-adverse-effects level (NOAEL) of $0.013 \mathrm{mg} / \mathrm{kg} / \mathrm{d}$. The tolerable daily intake (TDI) for birds was then calculated as the geometric mean of the NOAEL and LOAEL, or $0.031 \mathrm{mg} / \mathrm{kg} / \mathrm{d}$. Finally, assuming a food ingestion rate (IR)-to-BW ratio of 0.94 based on the Wilson's storm petrel, a dietary reference concentration of $0.033 \mathrm{mg} / \mathrm{kg}$ ww was derived. As noted in CCME 2000, this high IR:BW ratio means that the Wilson's storm petrel consumes almost its entire body weight daily, and is therefore be conservative for birds that feed at a lower rate.

The dietary TRV of $0.04 \mathrm{mg} / \mathrm{kg}$ ww was taken from Depew et al. 2012, who recently conducted a critical review of dietary methyl mercury toxicity thresholds for fish. They identified $0.04 \mathrm{mg} / \mathrm{kg}$ ww as a protective threshold, which was the highest unbounded NOAEL for reproductive effects in walleye (the lowest LOAEL was $0.05 \mathrm{mg} / \mathrm{kg}$ ww, so just marginally higher).

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Mean mercury concentrations in WB/muscle tissue for most fish species exceed the dietary mercury guideline for birds and TRV for fish (Figure 3). For those fish species collected from both Lake Koocanusa and non-mine influenced areas (bull trout, mountain whitefish, westslope cutthroat trout), mercury concentrations had considerable overlap (Figure 3). In general, however, mercury concentrations were greater in fish collected from Lake Koocanusa than in fish collected from non-mine influenced areas. To further evaluate the ubiquitous nature of mercury in fish, mercury concentrations measured in fish muscle collected from 21 national parks in the western US were compared to concentrations measured in the reservoir. Geometric mean concentrations in each park ranged from 0.033 to $0.33 \mathrm{mg} / \mathrm{kg} \mathrm{ww}$, with a grand mean of $0.10 \mathrm{mg} / \mathrm{kg}$ ww (Figure 3; Eagles-Smith et al. 2014). The geometric mean mercury concentration measured in fish collected from Glacier National Park, the park with the closest proximity to Lake Koocanusa, was $0.23 \mathrm{mg} / \mathrm{kg}$ ww. It should be noted that fish size and trophic status have an important influence on mercury concentrations in fish, but this was not factored into this evaluation.

## 2 SEDIMENT

### 2.1 Data

Sediment samples have been collected from Lake Koocanusa north and south of the border. North of the border, samples were collected in April 2013. Seven transects were sampled, with two upstream of the Elk River mouth and five downstream (Figure 4). Up to eight sediment grab samples were collected along each transect, including up to six submerged sediment samples and up to two samples collected above the water surface on the banks of the reservoir. Transects 2 and 4 (Figure 4) were sampled again in August 2013, following a historic flood event. The Montana Department of Environmental Quality (DEQ) collected sediment samples south of the border in November 2012 and June/July 2013 (Figure 5). Trace elements in sediment samples from Montana were analyzed in the $<63-\mu \mathrm{m}$ fraction.

### 2.2 Effects-based Benchmarks

Trace element concentrations were compared to one or more sediment quality benchmarks, as available:

- CCME Guidelines

o Interim sediment quality guidelines (ISQGs): These are equivalent to the threshold effect levels (TELs) derived by Smith et al. 1996, which are concentrations below which adverse effects are expected to rarely occur.
o Probable effect levels (PELs): These are equivalent to the TELs derived by Smith et al. 1996, which are concentrations above which adverse effects may be expected.
- BCMOE Guidelines
o Lowest effect levels (LELs): No effects on the majority of sediment-dwelling organisms are expected at concentrations less than the LEL.
o Severe effect levels (SELs): Adverse effects on the majority of sediment-dwelling organisms are expected at concentrations greater than the SEL.
- Consensus-based Guidelines (MacDonald et al. 2000)
o Threshold effect concentrations (TECs): These are based on the geometric mean of "threshold effect" concentrations from either the published literature or derived by various regulatory jurisdictions.
o Probable effect concentrations (PECs): These are based on the geometric mean of probable effect concentrations from either the published literature or derived by various regulatory jurisdictions.


### 2.3 Comparison of Concentrations to Benchmarks

Maximum concentrations of all trace elements measured in Lake Koocanusa, north and south of the border, never exceeded any probable effect sediment benchmark (e.g., PEL, SEL, or PEC). The only elements with concentrations that ever exceeded the highest threshold effect benchmark (e.g., ISQG, TEC) were arsenic, cadmium, iron, manganese, and nickel (Table 3; see also Attachment C). Of these, arsenic and cadmium only exceeded the highest threshold effect benchmark in $8 \%$ and $3 \%$ of the sediment samples, respectively (Table 3). Further, the maximum arsenic and cadmium concentrations only marginally exceeded their respective threshold effect benchmarks by factors of 1.3 and 1.0, respectively. Iron, manganese, and nickel concentrations exceeded their respective highest threshold effect benchmarks with greater frequency, but there was no spatial pattern with exceedances occurring upstream and downstream of the Elk River mouth (Table 3; Attachment C). Like arsenic and cadmium, the maximum iron, manganese, and nickel concentrations only marginally exceeded their respective threshold effect concentrations by factors of $1.2,1.7$, and 1.3 , respectively.


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Overall, the absence of any exceedances of probable effect benchmarks, when coupled with the low magnitudes of the exceedances of threshold effect benchmarks, indicates that trace elements in Lake Koocanusa sediment are not likely to adversely affect sediment-dwelling organisms under current conditions.

## 3 SURFACE WATER <br> 3.1 Data

Surface water samples have been collected from Lake Koocanusa (BC) since August 2013, monthly as conditions permit. Six stations have been sampled: two upstream of the mouth of the Elk River, three downstream of the mouth, and one in the east arm of the lake at the mouth of the Elk River (Figure 6). Temperature measurements were used to determine if the reservoir were stratified. If stratified, the epilimnion and hypolimnion were sampled at each station. If unstratified, samples were collected 3 m below the surface, $\sim 3 \mathrm{~m}$ above the substrate, and at an intermediate depth. The Montana Department of Environmental Quality (DEQ) has been collecting epilimnion and hypolimnion surface water samples in the same manner south of the border approximately monthly since November 2012 (Figure 7).

### 3.2 Effects-based Benchmarks

The effects-based benchmarks used to evaluate Lake Koocanusa surface water concentrations were primarily the approved or working BCMOE long-term water quality guidelines (WQGs) for the protection of freshwater aquatic life. Long-term WQGs are concentrations that should not be exceeded over a 30-day averaging period. The WQGs for seven constituents-cadmium, copper, lead, manganese, nickel, sulphate, and zinc-are dependent upon hardness. A hardness value of $100 \mathrm{mg} / \mathrm{L} \mathrm{CaCO}_{3}$ was used herein. The USEPA's draft water quality criterion of $1.3 \mu \mathrm{~g} / \mathrm{L}$ for lentic waters was not included in this evaluation, as the USEPA gives priority to selenium concentrations in fish tissue when those data are available (as is the case for Lake Koocanusa).

### 3.3 Comparison of Concentrations to WQGs

The only constituents that ever had concentrations exceeding their WQGs were iron, phosphorus, and selenium, and each only in a limited number of samples (Attachment D). Iron and phosphorous concentrations are associated with inputs from the Kootenay River and so, for
the purposes of this evaluation, do not appear to be associated with a point or non-point sources in the Elk Valley. Total selenium concentrations exceeded the WQG in 3 of 125 samples (2\%): two at the confluence of the Elk River (RG_EASTARM), and one north of the mouth of the Elk River (RG_USELK).

## 4 SUMMARY AND CONCLUSIONS

- A total of $6 \%$ of ovary selenium samples collected from Lake Koocanusa exceeded the BCMOE guideline of $11 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$, and $1 \%$ exceeded the draft USEPA criterion of $15.2 \mathrm{mg} / \mathrm{kg}$ dw.
- Integrating the cumulative distribution of ovary selenium concentrations in fish collected from Lake Koocanusa with the concentration-response curve for the most sensitive species tested to date (brown trout) resulted in a mean risk probability of $1.4 \%$ across all species and $1.9 \%$ for PMC, which has the highest ovary selenium concentrations.
- Selenium concentrations in fish tissues (WB/muscle and ovaries) collected from nonmine influenced areas exceed BCMOE selenium guidelines and draft USEPA selenium criteria more often than fish tissues collected from Lake Koocanusa.
- Element concentrations never exceeded probable effect levels in sediment, while five constituents (arsenic, cadmium, iron, manganese, nickel) exceeded the highest threshold effect levels.
- Selenium exceeded the WQG in 3 of 125 samples.
- The strongest line of evidence for evaluating potential risks due to selenium is the concentration in fish ovaries; data available to date indicates that selenium risks to fish in Lake Koocanusa are negligible.


## 5 REFERENCES

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## FIGURES



Figure 1. Comparison of mean selenium concentrations in fish species collected from both Lake Koocanusa and non-mine influenced areas (open circles represent individual samples). BT = bull trout; LNS = longnose sucker; MWF = mountain whitefish; NPM = northern pikeminnow; PMC = peamouth chub; WCT = westslope cutthroat trout.

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Figure 2. Cumulative distribution of fish ovary selenium concentrations from Lake Koocanusa and comparison to concentration-response data for brown trout.


Figure 3. Comparison of mean mercury concentrations in fish species collected from both Lake Koocanusa and non-mine influenced areas (open circles represent individual samples). $\mathrm{BRB}=$ burbot; $\mathrm{BT}=$ bull trout; $\mathrm{KKN}=$ kokanee; LNS = longnose sucker; LSS = largescale sucker; MWF = mountain whitefish; NPM = northern pikeminnow; PMC = peamouth chub; RBT = rainbow trout; WCT = westslope cutthroat trout.
*Mercury concentrations in fish collected from 21 National Parks in the western U.S. are provided for perspective: open circles represent geometric mean concentration for each National Park and column represents the grand mean.


Figure 4. Sediment sampling locations in Lake Koocanusa north of the border. All transects were sampled in April 2013 and transects 2 and 4 were re-sampled in August 2013 following an historic flood event.


Figure 5. Sediment sampling locations in Lake Koocanusa south of the border.


Figure 6. Surface water sampling locations in Lake Koocanusa north of the border.

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Figure 7. Surface water sampling locations in Lake Koocanusa south of the border.

## TABLES

Table 1. Summary of selenium concentrations ( $\mathrm{mg} / \mathrm{kg}$ dry weight) measured in fish tissue.


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${ }^{-}$- Includes all samples collected prior to 2005
Burbot biopsy concentrations are estimated due to uncertainties associated with moisture content and sample desiccation.

Table 2. Summary of selenium concentrations ( $\mathrm{mg} / \mathrm{kg}$ dry weight) measured in fish reproductive tissue.

| Species Year <br> Kokanee (KKN) | Tissue | Lake Koocanusa |  |  |  |  |  |  |  |  |  | Non-mine influenced locations |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | N | Min | Max | Average | Reservoir samples exceeding criteria |  |  |  |  |  | N | Min | Max | Average | Non-mine influenced samples exceeding criteria |  |  |  |  |  |
|  |  |  |  |  |  | BC WQG |  | $\begin{aligned} & \text { EPA Approved } \\ & \text { (Kentucky) } \end{aligned}$ |  | EPA Draft |  |  |  |  |  | BC WQG |  | EPA Approved (Kentucky) |  | EPA Draft |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2008 | Gonads Ovary | $\begin{aligned} & 40 \\ & 18 \end{aligned}$ | 2.9 2.8 | 4.9 4.8 | $\begin{aligned} & 3.7 \\ & 3.8 \end{aligned}$ | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & \text { 0\% } \\ & \text { 0\% } \end{aligned}$ | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & 0 \% \\ & 0 \% \end{aligned}$ | 0 | $\begin{aligned} & \text { 0\% } \\ & \text { 0\% } \end{aligned}$ |  |  |  |  |  |  |  |  |  |  |
| 2013 | Gonads | 28 | 3.1 | 5.6 | 4.2 | 0 | 0\% | 0 | 0\% | 0 | 0\% |  |  |  |  |  |  |  |  |  |  |
| Longnose sucker (LNS) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2008 | Gonads | 8 | 4.0 | 5.6 | 4.8 | 0 | 0\% | 0 | 0\% | 0 | 0\% |  |  |  |  |  |  |  |  |  |  |
| 2009 | Ovary |  |  |  |  |  |  |  |  |  |  | 4 | 4.2 | 5.7 | 5.2 | 0 | 0\% | 0 | 0\% | 0 | 0\% |
| 2012 | Ovary |  |  |  |  |  |  |  |  |  |  | 4 | 4.2 | 5.1 | 4.8 | 0 | 0\% | 0 | 0\% | 0 | 0\% |
| 2013 | Gonads | 1 | 6.9 | 6.9 | 6.9 | 0 | 0\% | 0 | 0\% | 0 | 0\% |  |  |  |  |  |  |  |  |  |  |
| Largescale sucker (LSS) | Ovary | 1 | 3.9 | 3.9 | 3.9 | 0 | 0\% | 0 | 0\% | 0 | 0\% |  |  |  |  |  |  |  |  |  |  |
| Mountain whitefish (MWF) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| $2005{ }^{\text {a }}$ | Ovary |  |  |  |  |  |  |  |  |  |  | 4 | 19 | 23 | 20 | 4 | 100\% | 2 | 50\% | 4 | 100\% |
| $\begin{aligned} & 2006 \\ & 2000 \end{aligned}$ | Ovary |  |  |  |  |  |  |  |  |  |  | 5 | 15 | 42 | 30 | 5 | 100\% | 4 | 80\% | 5 | 100\% |
|  | Gonads |  |  |  |  |  |  |  |  |  |  | 8 | 21 | 36 | 29 | 8 | 100\% | 8 | 100\% | 8 | 100\% |
|  | Ovary | 1 | 13 | 13 | 13 | 1 | 100\% | 0 | 0\% | 0 | 0\% | 10 | 19 | 33 | 26 | 10 | 100\% | 9 | 90\% | 10 | 100\% |
|  | Ovary | 6 | 8.9 | 24 | 17 | 5 | 83\% |  | 50\% | 3 | 50\% | 11 | 6.8 | 42 | 22 | 10 | 91\% | 6 | 55\% | 9 | 82\% |
| Northern pikeminnow (NPM) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 36 | 2.5 | 5.9 | 3.6 | 0 | 0\% | 0 | 0\% | 0 | 0\% |  |  |  |  |  |  |  |  |  |  |
| 2009 | Gonads |  |  |  |  |  |  |  |  |  |  | 11 | 0.80 | 5.0 | 2.6 | 0 | 0\% | 0 | 0\% | 0 | 0\% |
| Peamouth chub (PMC) <br> 2008 | Gonads | 24 | 2.4 | 8.1 | 3.9 | 0 | 0\% | 0 | 0\% | 0 | 0\% |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Gonads | 40 | 4.0 | 12 | 7.3 | 4 | 10\% | 0 | 0\% | 0 | 0\% | 9 | 2.9 | 11 | 7.3 | 0 | 0\% | 0 | 0\% | 0 | 0\% |
|  | Ovary | 10 | 5.0 | 11 | 7.8 | 1 | 10\% | 0 | 0\% |  | 0\% |  |  |  |  |  |  |  |  |  |  |
|  | Gonads | 31 | 5.4 | 22 | 9.1 | 6 | 19\% | 1 | 3\% | 2 | 6\% |  |  |  |  |  |  |  |  |  |  |
| Rainbow trout (RBT) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2013 | Gonads | 2 | 4.7 | 4.8 | 4.7 | 0 | 0\% | 0 | 0\% | 0 | 0\% |  |  |  |  |  |  |  |  |  |  |
| Westslope cutthroat trout (WCT) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Ovary |  |  |  |  |  |  |  |  |  |  | 39 | 2.0 | 17 | 8.4 | ${ }^{13}$ | 33\% | 0 | 0\% |  | 5\% |
| 2006 | Ovary |  |  |  |  |  |  |  |  |  |  | 20 | 4.6 | 14 | 7.8 |  | 10\% | 0 | 0\% | 0 | 0\% |
| 2008 | Ovary |  |  |  |  |  |  |  |  |  |  | 4 | 4.3 | 7.3 | 6.1 | 0 | 0\% | 0 | 0\% | 0 | 0\% |
| 2009 | Ovary | 6 | 6.7 | 17 | 11 | 3 | 50\% | 0 | 0\% | 1 | 17\% | 9 | 11 | 17 | 15 | 9 | 100\% | 0 | 0\% | 6 | 67\% |
| 2013 | Gonads | 1 | 10 | 10 | 10 | 0 | 0\% | 0 | 0\% | 0 | 0\% |  |  |  |  |  |  |  |  |  |  |
| Total | Ovary | 42 |  |  |  | 7 | 17\% | 3 | 7\% | 3 | 7\% | 110 |  |  |  | 53 | 48\% | 21 | 19\% | 36 | 33\% |
|  | Gonad | 211 |  |  |  | 10 | 5\% | 1 | 0\% | 2 | 1\% | 28 |  |  |  | 8 | 29\% | 8 | 29\% | 8 | 29\% |
|  | Grand Total = | 253 |  |  |  | 17 | 7\% | 4 | 2\% | 5 | 2\% | 138 |  |  |  | 61 | 44\% | 29 | 21\% | 44 | 32\% |
| Total (minus MWF) | Ovary | 35 |  |  |  | 4 | 11\% | 0 | 0\% | 1 | 3\% | 80 |  |  |  | 24 | 30\% | 0 | 0\% | 8 | 10\% |
|  | Gonad | 211 |  |  |  | 10 | 5\% | 1 | 0\% | 2 | 1\% | 20 |  |  |  | 0 | 0\% | 0 | 0\% | 0 | 0\% |
|  | Grand Total = | 246 |  |  |  | 14 | 6\% | 1 | 0\% | 3 | 1\% | 100 |  |  |  | 24 | 24\% | 0 | 0\% | 8 | 8\% |

Table 3. Numbers of samples exceeding low effect and probable effect sediment quality guidelines for aquatic like in Lake Koocanusa.

| Location Name | Description | \# of Samples Greater than SQG / Total \# of Samples |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Arsenic |  | Cadmium |  | Iron |  | Manganese |  | Nickel |  |
|  |  | LowerSQG | UpperSQG | LowerSQG | UpperSQG | LowerSQG | UpperSQG | LowerSQG | UpperSQG | LowerSQG | UpperSQG |
| Transect 1 | South of Kootenay Mouth | 0/7 | 0/7 | 0/7 | 0/7 | 2/7 | 0/7 | 2/7 | 0/7 | 0/7 | 0/7 |
| Transect 2 | North of the Elk River Mouth | 0/12 | 0/12 | 0/12 | 0/12 | 12/12 | 0/12 | 10/12 | 0/12 | 5/12 | 0/12 |
| Transect 3 | South of the Elk River Mouth | 0/7 | 0/7 | 0/7 | 0/7 | 2/7 | 0/7 | 2/7 | 0/7 | 0/7 | 0/7 |
| Transect 4 |  | 0/12 | 0/12 | 2/12 | 0/12 | 9/12 | 0/12 | 10/12 | 0/12 | 5/12 | 0/12 |
| Transect 5 |  | 0/6 | 0/6 | 0/6 | 0/6 | 3/6 | 0/6 | 4/6 | 0/6 | 0/6 | 0/6 |
| Transect 6 |  | 0/5 | 0/5 | 0/5 | 0/5 | 0/5 | 0/5 | $2 / 5$ | 0/5 | 0/6 | 0/5 |
| Transect 7 |  | 0/5 | 0/5 | 0/5 | 0/5 | 3/5 | 0/5 | 5/5 | 0/5 | 0/6 | 0/5 |
| K01KOOCL01 | International Boundary | 2/9 | 0/9 | 0/9 | 0/9 | 0/8 | 0/8 | na | na | na | na |
| K01KOOCL02 | Near Dodge Creek mouth | 0/1 | 0/1 | 0/1 | 0/1 | na | na | na | na | na | na |
| K01KOOCL03 | Tenmile | 3/8 | 0/8 | 0/8 | 0/8 | 0/8 | 0/8 | na | na | na | na |
| K01KOOCL04 | Forebay | 1/8 | 0/8 | 0/8 | 0/8 | 0/8 | 0/8 | na | na | na | na |
| Total $=$ |  | 6/80 | 0/80 | 2/80 | 0/80 | 31/78 | 0/78 | 35/54 | 0/54 | 10/56 | 0/56 |
| Percent Observed to Exceed SQG = |  | 8\% | 0\% | 3\% | 0\% | 39\% | 0\% | 65\% | 0\% | 18\% | 0\% |

Notes: 1. Lower-SQGs include: Lowest Effects Level (LEL), Threshold Effect Level (TEL), Interim Sediment Quality Guideline (ISQG), and/or Threshold Effects Concentration (TEC)
2. Upper SQGs include: Probable Effects Level (PEL), Severe Effects Level (SEL), and/or Probable Effects Concentration (PEC).
3. Transects 1 through 7 were collected in British Columbia, K01KOOCL01 through K01KOOCL04 were collected in Montana.
4. "na" = not analyzed.
5. Sediments collected in Montana are the $<63 \mu \mathrm{~m}$ fraction.
6. Arsenic SQGs (Lower $=9.8 \mu \mathrm{~g} / \mathrm{g}$; Upper $=33 \mu \mathrm{~g} / \mathrm{g}$ ); Cadmium SQGs (Lower $=0.99 \mu \mathrm{~g} / \mathrm{g}$; Upper $=5.0 \mu \mathrm{~g} / \mathrm{g}$ ); Iron SQGs (Lower $=21,200 \mu \mathrm{~g} / \mathrm{g}$; Upper $=$ $43,766 \mu \mathrm{~g} / \mathrm{g}$ ); Manganese SQGs (Lower $=460 \mu \mathrm{~g} / \mathrm{g}$; Upper = $1100 \mu \mathrm{~g} / \mathrm{g}$ ); and Nickel SQGs (Lower = $22.7 \mu \mathrm{~g} / \mathrm{g}$; Upper $=48.6 \mu \mathrm{~g} / \mathrm{g}$ )

## ATTACHMENT A

Plots of Selenium Concentrations in Fish Tissues (Whole Body and Muscle)

## Summary figures showing fish tissue concentrations in Lake Koocanusa

The following is a series of box-\&-whisker plots showing selenium concentrations measured in tissue samples collected from reference areas and within Lake Koocanusa since 1996.

Ref. Locations (NMI) in the Elk Valley and Lake Koocanusa (upstream of mining activities) 591 samples collected from 31 locations
Lake Koocanusa
680 samples collected from 33 locations
Fish tissue includes muscle samples and whole fish.
Concentrations are presented with the y-axis on a log-scale
Results not detected are included at the reported detection limit.

Parameters shown on a wet weight basis were converted from the dry weight results as follows:
$\mathrm{mg} / \mathrm{kg}$ wet-weight $=[\mathrm{mg} / \mathrm{kg}$ dry-weight $]$ * [ 1 - (percent moisture)/100]
if percent moisture was not reported, the average moisture from the same location and tissue type from other years was used.

## LEGEND



Comparison guidelines
$B C$ WQG for aquatic life $4 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ selenium
EPA Approved (Kentucky) $8.6 \mathrm{mg} / \mathrm{kg}$ dw whole body

$8.1 \mathrm{mg} / \mathrm{kg}$ dw whole body
$11.8 \mathrm{mg} / \mathrm{kg}$ dw muscle
BC WQG for selenium update (2012)
Kentucky Division of Water (2013)
Draft U.S. EPA (2014)
The draft 2014 EPA criteria are presented for illustration purposes only. Public comment and external peer review are necessary before the values are finalized.
These values are subject to change.
Ref. Locations (NMI) = Non-mine Influenced Areas as classified by previous studies.

Feeding guild (species included)
O Insectivores (Westslope cutthroat trout, Mountain whitefish, Lake whitefish, Kokanee)

- Benthivores (Longnose sucker, Largescale sucker, Sculpin)
- Omnivores (Peamouth chub, Brook trout, Rainbow trout)

O Piscivores (Bull trout, Lake trout, Northern pikeminnow, Burbot)

Burbot biopsyconcentrations are estimated due to uncertainties associated with moisture content and sample desication.

Fish tissue concentrations from Lake Koocanusa by feeding guild


## Summary figures showing fish tissue concentrations in Lake Koocanusa

The following is a series of box-\&-whisker plots showing selenium concentrations measured in tissue samples collected from reference areas and within Lake Koocanusa since 1996.

Ref. Locations (NMI) in the Elk Valley and Lake Koocanusa (upstream of mining activities) 591 samples collected from 31 locations
Lake Koocanusa
680 samples collected from 33 locations
Fish tissue includes muscle samples and whole fish.
Concentrations are presented with the y-axis on a log-scale
Results not detected are included at the reported detection limit.

Parameters shown on a wet weight basis were converted from the dry weight results as follows:
$\mathrm{mg} / \mathrm{kg}$ wet-weight $=[\mathrm{mg} / \mathrm{kg}$ dry-weight $]$ * [ 1 - (percent moisture)/100]
if percent moisture was not reported, the average moisture from the same location and tissue type from other years was used.

## LEGEND



Comparison guidelines
$B C$ WQG for aquatic life $4 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ selenium
EPA Approved (Kentucky) $8.6 \mathrm{mg} / \mathrm{kg}$ dw whole body

$8.1 \mathrm{mg} / \mathrm{kg}$ dw whole body
$11.8 \mathrm{mg} / \mathrm{kg}$ dw muscle
BC WQG for selenium update (2012)
Kentucky Division of Water (2013)
Draft U.S. EPA (2014)
The draft 2014 EPA criteria are presented for illustration purposes only. Public comment and external peer review are necessary before the values are finalized.
These values are subject to change.
Ref. Locations (NMI) = Non-mine Influenced Areas as classified by previous studies.

Species

| $\boldsymbol{\nabla}$ | Westslope cutthroat trout (WCT) | $\boldsymbol{\nabla}$ | Sculpin (SCU) |
| :--- | :--- | ---: | :--- |
| $\boldsymbol{\nabla}$ | Peamouth chub (PMC) | $\boldsymbol{\nabla}$ | Rainbow trout (RBT) |
| $\boldsymbol{\nabla}$ | Kokanee (KKN) | $\boldsymbol{\nabla}$ | Lake whitefish (LWF) |
| $\boldsymbol{\nabla}$ | Northern pikeminnow (NPM) | $\boldsymbol{\nabla}$ | Lake trout (LT) |
| $\boldsymbol{\nabla}$ | Mountain whitefish (MWF) | $\boldsymbol{\nabla}$ | Largescale sucker (LSS) |
| $\boldsymbol{\nabla}$ | Longnose sucker (LNS) | $\boldsymbol{\nabla}$ | Brook trout (EB) |
| $\boldsymbol{\nabla}$ | Bull trout (BT) | 0 | Burbot (BRB) |

Burbot biopsyconcentrations are estimated due to uncertainties associated with moisture content and sample desication.

Fish tissue concentrations from Lake Koocanusa by species


Fish tissue concentrations from Lake Koocanusa - BT only


Fish tissue concentrations from Lake Koocanusa - BT only


Fish tissue concentrations from Lake Koocanusa - LNS only


Fish tissue concentrations from Lake Koocanusa - LNS only


Fish tissue concentrations from Lake Koocanusa - MWF only


Fish tissue concentrations from Lake Koocanusa - MWF only


Fish tissue concentrations from Lake Koocanusa - NPM only


Fish tissue concentrations from Lake Koocanusa - NPM only


Fish tissue concentrations from Lake Koocanusa - PMC only


Fish tissue concentrations from Lake Koocanusa - PMC only


Fish tissue concentrations from Lake Koocanusa - WCT only


Fish tissue concentrations from Lake Koocanusa - WCT only


Fish tissue concentrations from Lake Koocanusa - KKN only


Fish tissue concentrations from Lake Koocanusa - RBT only


Fish tissue concentrations from Lake Koocanusa - LSS only


Fish tissue concentrations from Lake Koocanusa - BRB only


## ATTACHMENT B

Plots of Selenium Concentrations in Fish Reproductive Tissues (Ovaries)

## Summary figures showing fish reproductive tissue concentrations in Lake Koocanusa

The following is a series of box-\&-whisker plots showing selenium concentrations measured in tissue samples collected from reference areas and within Lake Koocanusa since 1996.

Ref. Locations (NMI) in the Elk Valley and Lake Koocanusa (upstream of mining activities) 138 samples collected from 14 locations
Lake Koocanusa
253 samples collected from 10 locations
Fish reproductive tissue includes ovary and gonad samples.
Concentrations are presented with the y-axis on a log-scale
Results not detected are included at the reported detection limit.
Parameters shown on a wet weight basis were converted from the dry weight results as follows:
$\mathrm{mg} / \mathrm{kg}$ wet-weight $=[\mathrm{mg} / \mathrm{kg}$ dry-weight $]$ * [ 1 - (percent moisture)/100]
if percent moisture was not reported, the average moisture from the same location and tissue type from other years was used.

## LEGEND



Comparison guidelines
BC WQG for aquatic life $11 \mathrm{mg} / \mathrm{kg}$ dw selenium
EPA Approved (Kentucky) $19.3 \mathrm{mg} / \mathrm{kg}$ dw ovary

15.2 mg/kg dw ovary

BC WQG for selenium update (2012)
Kentucky Division of Water (2013)
Draft U.S. EPA (2014)
The draft 2014 EPA criteria are presented for illustration purposes only. Public comment and external peer review are necessary before the values are finalized.
These values are subject to change.
Ref. Locations (NMI) = Non-mine Influenced Areas as classified by previous studies.

Feeding guild (species included)
O Insectivores (Westslope cutthroat trout, Mountain whitefish, Kokanee)

- Benthivores (Longnose sucker, Largescale sucker)
- Omnivores (Peamouth chub, Rainbow trout)

O Piscivores (Northern pikeminnow,

Fish Reproductive tissue concentrations from Lake Koocanusa by feeding guild


## Summary figures showing fish reproductive tissue concentrations in Lake Koocanusa

The following is a series of box-\&-whisker plots showing selenium concentrations measured in tissue samples collected from reference areas and within Lake Koocanusa since 1996.

Ref. Locations (NMI) in the Elk Valley and Lake Koocanusa (upstream of mining activities) 138 samples collected from 14 locations
Lake Koocanusa
253 samples collected from 10 locations
Fish reproductive tissue includes ovary and gonad samples.
Concentrations are presented with the y-axis on a log-scale
Results not detected are included at the reported detection limit.
Parameters shown on a wet weight basis were converted from the dry weight results as follows:
$\mathrm{mg} / \mathrm{kg}$ wet-weight $=[\mathrm{mg} / \mathrm{kg}$ dry-weight $]$ * [ 1 - (percent moisture)/100]
if percent moisture was not reported, the average moisture from the same location and tissue type from other years was used.

## LEGEND



Comparison guidelines
$B C W Q G$ for aquatic life $11 \mathrm{mg} / \mathrm{kg}$ dw selenium
EPA Approved (Kentucky) $19.3 \mathrm{mg} / \mathrm{kg}$ dw ovary

15.2 mg/kg dw ovary

BC WQG for selenium update (2012)
Kentucky Division of Water (2013)
Draft U.S. EPA (2014)
The draft 2014 EPA criteria are presented for illustration purposes only. Public comment and external peer review are necessary before the values are finalized.
These values are subject to change.
Ref. Locations (NMI) = Non-mine Influenced Areas as classified by previous studies.

Species
$\boldsymbol{\nabla}$ Westslope cutthroat trout (WCT)
Rainbow trout (RBT)
$\nabla$ Peamouth chub (PMC)
$\nabla$ Largescale sucker (LSS)
Kokanee (KKN)
$\nabla$ Northern pikeminnow (NPM)
$\nabla$ Mountain whitefish (MWF)
$\nabla$ Longnose sucker (LNS)

Fish Reproductive tissue concentrations from Lake Koocanusa by species


Fish Reproductive tissue concentrations from Lake Koocanusa - LNS only


Fish Reproductive tissue concentrations from Lake Koocanusa - LNS only


Fish Reproductive tissue concentrations from Lake Koocanusa - MWF only


Fish Reproductive tissue concentrations from Lake Koocanusa - MWF only


Fish Reproductive tissue concentrations from Lake Koocanusa - NPM only


Fish Reproductive tissue concentrations from Lake Koocanusa - NPM only


Fish Reproductive tissue concentrations from Lake Koocanusa - PMC only


Fish Reproductive tissue concentrations from Lake Koocanusa - PMC only


Fish Reproductive tissue concentrations from Lake Koocanusa - WCT only


Fish Reproductive tissue concentrations from Lake Koocanusa - WCT only


Fish Reproductive tissue concentrations from Lake Koocanusa - KKN only


Fish Reproductive tissue concentrations from Lake Koocanusa - RBT only


Fish Reproductive tissue concentrations from Lake Koocanusa - LSS only


## ATTACHMENT C

Plots of Selenium Concentrations in Sediment

## Summary figures showing sediment concentrations from Lake Koocanusa

Sediment samples were collected from throughout Lake Koocanusa, including Canada and the US, from November 2012 to August 2013.

Lake Koocanusa in Canada
64 samples from 7 transects
Lake Koocanusa in the U.S.
26 samples from 4 locations

Concentrations were measured on bulk sediment (or 1 mm sieved) and the finer 0.063 mm sieved fraction. Results not detected are included at the reported detection limit.

LEGEND


| Canadian | U.S. | Comparison Guidelines |
| :---: | :---: | :---: |
| Transects | Locations | Long-term sediment quality guideline, British Columbia |
| - Transect 1 | - K01KOOCL01 |  |
| - Transect 2 | - K01KOOCL02 | CCME, Probable effect level (PEL) |
| - Transect 3 | - K01KOOCL03 | CCME, Interim sediment quality guideline (ISQG) |
| - Transect 4 | - K01KOOCL04 | BC MOE, Probable effect level (PEL) |
| - Transect 5 |  | - - - BC MOE, Lowest effect level (LEL) |
| - Transect 6 |  |  |
| - Transect 7 |  | - _ - Consensus-based, Probable effect Iconcentration (PEC) |

Moisture in sediment from Lake Koocanusa


Total Organic Carbon in sediment from Lake Koocanusa


## Sulfur in sediment from Lake Koocanusa



Aluminum in sediment from Lake Koocanusa


Antimony in sediment from Lake Koocanusa


Arsenic in sediment from Lake Koocanusa


Barium in sediment from Lake Koocanusa


Beryllium in sediment from Lake Koocanusa


Bismuth in sediment from Lake Koocanusa


Boron in sediment from Lake Koocanusa



Calcium in sediment from Lake Koocanusa



Cobalt in sediment from Lake Koocanusa





Lithium in sediment from Lake Koocanusa


Magnesium in sediment from Lake Koocanusa


## Manganese in sediment from Lake Koocanusa



Mercury in sediment from Lake Koocanusa


Molybdenum in sediment from Lake Koocanusa


Nickel in sediment from Lake Koocanusa


Phosphorus in sediment from Lake Koocanusa


Potassium in sediment from Lake Koocanusa


Selenium in sediment from Lake Koocanusa


## Silver in sediment from Lake Koocanusa



Sodium in sediment from Lake Koocanusa


## Strontium in sediment from Lake Koocanusa



## Thallium in sediment from Lake Koocanusa



Tin in sediment from Lake Koocanusa


Titanium in sediment from Lake Koocanusa


## Uranium in sediment from Lake Koocanusa



Vanadium in sediment from Lake Koocanusa


Zinc in sediment from Lake Koocanusa


## ATTACHMENT D

Plots of Selenium Concentrations in Surface Water

## Summary figures showing analyte concentrations in the Elk Valley (Management Unit 6) and Lake Koocanusa samples collected by the state of Montana

The following is a series of box-and-whisker plots and time-series plots for analyte concentrations in surface waters collected from Lake Koocanusa and at or near the mouth of the Elk River. Data shown in the plots that follow are for locations within Management Unit 6 (MU6) and also for locations south of the International border (i.e., in Montana). All stations are identified in the box-and-whisker plots. Description of the stations included is as follows:

```
Lake Koocanusa northern portion (RG_WARDB)
Lake Koocanusa upstream of Elk River (RG_USELK)
Elk River at highway 93 bridge; BC monitoring station (BC08NK0003)
Elk River at the mouth (RG_ELKMOUTH)
Lake Koocanusa near the mouth of Elk River (RG_EASTARM)
Lake Koocanusa downstream of Elk River (RG_DSELK)
Lake Koocanusa downstream of Elk River (RG_GRASMERE)
Lake Koocanusa near the border with U.S. (RG_BORDER)
Lake Koocanusa at International boundary; MT DEQ (K01KOOCL01)
Lake Koocanusa near the mouth of Dodge Creek; MT DEQ (K01KOOCL02)
Lake Koocanusa near Tenmile Creek; MT DEQ (K01KOOCLO3)
Lake Koocanusa in forebay; MT DEQ (K01KOOCL04)
```

On the upper panel of each page, box-and-whisker plots are presented to illustrate the statistical properties of each station (see legend below for description of the box-and-whisker statistics). Data for these stations progress from upstream to downstream. Data for the Elk River stations are between the thin vertical lines. The remaining data are for Lake Koocanusa. A thick vertical line indicates the International border. Total concentrations are shown with blue data points and dissolved concentrations are shown with black data points, with the exception of the data plotted in the remaining time-series panels. Green data points in the top panel represent total concentrations and are shown as a time-series in the middle panel. Orange data points in the top panel represent dissolved concentrations and are shown as time-series in the bottom panel. Below detection limit samples (BDLs) are plotted as " $<$ ", and are plotted at the detection limit. For constituents where water quality guidelines (WQGs) exist, the guideline value(s) is also shown. Long-term WQGs are shown with a dashed orange line, whereas short-term WQGs are shown with a solid orange line. Hardness-based WQGs are shown as the WQG calculated with median hardness from appropriate locations (i.e. for Lake Koocanusa the median hardness is calculated from the Lake Koocanusa stations considered in this analysis; for the Elk River, the median hardness is calculated from the upstream Elk River station, GH_ER2). Summary statistics for the total and dissolved fractions are provided at the bottom of the page, if applicable. Maximum likelihood estimation (MLE) methods were used to calculate summary statistics if the proportion of BDLs was greater than $0 \%$, but less than $80 \%$. In addition to summary statistics for each station, the $90^{\text {th }}$ and $95^{\text {th }}$ percentiles are shown for the upstream Lake Koocanusa station (i.e. RG_WARDB); they are described as: "U/S $90^{\text {th }} \%$ \%tile" and "U/S 95 ${ }^{\text {th }} \%$ tile".

For most analytes, concentrations are shown with y-axis on a log-scale because of wide ranging concentrations and to allow for comparison with WQGs (which may be much higher than reported analyte concentrations). For alkalinity, dissolved organic carbon, hardness, and total suspended solids, pH , concentrations are shown with linear y-axes.

## LEGEND





















|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  | 212 |
| Geo_mean | 64.7 | 58.6 | 72.2 |
| Median | 64.7 | 58.6 | 44.8 |
| Mle_used | $Y$ | Y | N |
| Dist | lognormal | lognormal | no_dist |
| N_total | 515 | 177 | 44 |
| N_bdl | 5 | 1 | 0 |
| N_non_bdl | 510 | 176 | 44 |
| Min_detect | 0.6 | 0.6 | 6.1 |
| Max_detect | 9850 | 3830 | 1570 |
| Min_date | $1990-02-12$ | $2004-01-26$ | $2011-01-17$ |
| Max_date | $2013-05-13$ | $2013-05-13$ | $2013-05-13$ |
| U/S 90th \%tile | 620 |  |  |
| U/S 95th \%tile | 857 |  |  |


|  | DISSOLVED |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  |  |
| Geo_mean | 2.56 | 2.42 | 3.25 |
| Median | 2.56 | 2.42 | 3.25 |
| Mle_used | $Y$ | Y | Y |
| Dist | lognormal | lognormal | lognormal |
| N_total | 183 | 165 | 44 |
| N_bdl | 7 | 7 | 1 |
| N_non_bdl | 176 | 158 | 43 |
| Min_detect | 0.2 | 0.2 | 0.5 |
| Max_detect | 709 | 510 | 111 |
| Min_date | $2003-04-07$ | $2004-01-26$ | $2011-01-17$ |
| Max_date | $2013-05-13$ | $2013-05-13$ | $2013-05-13$ |
| U/S 90th \%tile | 12.8 |  |  |
| U/S 95th \%tile | 16.6 |  |  |



































































































|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  |  |
| Geo_mean | 0.00128 | 0.0014 | 0.0017 |
| Median | 0.00128 | 0.0014 | 0.0017 |
| Mle_used | Y | Y | Y |
| Dist | lognormal | lognormal | lognormal |
| N_total | 198 | 177 | 44 |
| N_bdl | 79 | 66 | 16 |
| N_non_bdl | 119 | 111 | 28 |
| Min_detect | 0.001 | 0.001 | 0.001 |
| Max_detect | 0.043 | 0.043 | 0.031 |
| Min_date | $2003-03-09$ | $2004-01-26$ | $2011-01-17$ |
| Max_date | $2013-05-13$ | $2013-05-13$ | $2013-05-13$ |
| U/S 90th \%tile | 0.5 |  |  |
| U/S 95th \%tile | 0.5 |  |  |


|  | DISSOLVED |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 0.00113 | 0.00112 | 0.00116 |
| Geo_mean | 0.00105 | 0.00105 | 0.00106 |
| Median | 0.001 | 0.001 | 0.001 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 183 | 165 | 44 |
| N_bdl | 158 | 141 | 36 |
| N_non_bdl | 25 | 24 | 8 |
| Min_detect | 0.001 | 0.001 | 0.001 |
| Max_detect | 0.007 | 0.007 | 0.007 |
| Min_date | $2003-04-07$ | $2004-01-26$ | $2011-01-17$ |
| Max_date | $2013-05-13$ | $2013-05-13$ | $2013-05-13$ |
| U/S 90th \%tile | 0.5 |  |  |
| U/S 95th \%tile | 0.5 |  |  |




















|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  |  |
| Geo_mean | 10.5 | 10.5 | 10.5 |
| Median | 10.5 | 10.5 | 10.5 |
| Mle_used | Y | Y | Y |
| Dist | lognormal | lognormal | lognormal |
| N_total | 7 | 7 | 7 |
| N_bdl | 3 | 3 | 3 |
| N_non_bdl | 4 | 4 | 4 |
| Min_detect | 11 | 11 | 11 |
| Max_detect | 13 | 13 | 13 |
| Min_date | $2013-08-06$ | $2013-08-06$ | $2013-08-06$ |
| Max_date | $2014-01-07$ | $2014-01-07$ | $2014-01-07$ |
| U/S 90th \%tile | 12.7 |  |  |
| U/S 95th \%tile | 13.4 |  |  |


|  | DISSOLVED |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 10 | 10 | 10 |
| Geo_mean | 10 | 10 | 10 |
| Median | 10 | 10 | 10 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 7 | 7 | 7 |
| N_bdl | 7 | 7 | 7 |
| N_non_bdl | 0 | 0 | 0 |
| Min_detect |  |  |  |
| Max_detect |  |  |  |
| Min_date | $2013-08-06$ | $2013-08-06$ | $2013-08-06$ |
| Max_date | $2014-01-07$ | $2014-01-07$ | $2014-01-07$ |
| U/S 90th \%tile | 10 |  |  |
| U/S 95th \%tile | 10 |  |  |




















































| $10^{2}$ | Dissolved |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  |
|  | 08/15/2013 |  | 09/01/2013 |  | 09/15/2013 | 10/01/2013 | 10/15/ |  | 11/01/2013 |
|  | TOTAL |  |  |  |  | DISSOLVED |  |  |  |
|  | Parameter |  | Last 10 yrs |  |  | Parameter |  | Last 10 yrs |  |
|  | Mean | 38.2 | $38.2$ | $38.2$ |  | Mean | $37.5$ | $37.5$ | $37.5$ |
|  | Geo_mean | 38.1 | 38.1 | 38.1 |  | Geo_mean | 37.4 | 37.4 | 37.4 |
|  | Median | 38.9 | 38.9 | 38.9 |  | Median | 38 | 38 | 38 |
|  | Mle_used | N | N | N |  | Mle_used | N | N | N |
|  |  | no_dist | no_dist | no_dist |  | Dist | no_dist | no_dist | no_dist |
|  | N_total | $13$ | $13$ | $13$ |  | N_total | $13$ | $13$ | $13$ |
|  | N_bdl | $0$ | $0$ | $0$ |  | N_bdl | $0$ | $0$ | $0$ |
|  | N_non_bdl | 13 | 13 | 13 |  | N_non_bdl | 13 | 13 | 13 |
|  | Min_detect | 33.6 | 33.6 | 33.6 |  | Min_detect | 32.3 | 32.3 | 32.3 |
|  | Max_detect | 45.3 | 45.3 | 45.3 |  | Max_detect | 45.5 | 45.5 | 45.5 |
|  | Min_date | 2013-08-07 | 2013-08-07 | 2013-08-07 |  | Min_date | 2013-08-07 | 2013-08-07 | 2013-08-07 |
|  | Max_date | 2013-11-06 | 2013-11-06 | 2013-11-06 |  | Max_date | 2013-11-06 | 2013-11-06 | 2013-11-06 |
|  | U/S 90th \%tile | $45.8$ |  |  |  | U/S 90th \%tile | $45.5$ |  |  |
|  | U/S 95th \%tile | $47.9$ |  |  |  | U/S 95th \%tile |  |  |  |






|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 57.4 | 57.4 | 57.4 |
| Geo_mean | 57.3 | 57.3 | 57.3 |
| Median | 56.6 | 56.6 | 56.6 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 16 | 16 | 16 |
| N_bdl | 0 | 0 | 0 |
| N_non_bdl | 16 | 16 | 16 |
| Min_detect | 51 | 51 | 51 |
| Max_detect | 66.2 | 66.2 | 66.2 |
| Min_date | $2011-09-06$ | $2011-09-06$ | $2011-09-06$ |
| Max_date | $2014-01-07$ | $2014-01-07$ | $2014-01-07$ |
| U/S 90th \%tile | 45.8 |  |  |
| U/S 95th \%tile | 47.9 |  |  |


|  | DISSOLVED |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 57 | 57 | 57 |
| Geo_mean | 56.8 | 56.8 | 56.8 |
| Median | 55.5 | 55.5 | 55.5 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 16 | 16 | 16 |
| N_bdl | 0 | 0 | 0 |
| N_non_bdl | 16 | 16 | 16 |
| Min_detect | 51.9 | 51.9 | 51.9 |
| Max_detect | 67.8 | 67.8 | 67.8 |
| Min_date | $2011-09-06$ | $2011-09-06$ | $2011-09-06$ |
| Max_date | $2014-01-07$ | $2014-01-07$ | $2014-01-07$ |
| U/S 90th \%tile | 45.5 |  |  |
| U/S 95th \%tile | 48 |  |  |














|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 34 | 34 | 34 |
| Geo_mean | 34 | 34 | 34 |
| Median | 34 | 34 | 34 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 2 | 2 | 2 |
| N_bdl | 0 | 0 | 0 |
| N_non_bdl | 2 | 2 | 2 |
| Min_detect | 34 | 34 | 34 |
| Max_detect | 34 | 34 | 34 |
| Min_date | $2012-11-14$ | $2012-11-14$ | $2012-11-14$ |
| Max_date | $2012-11-14$ | $2012-11-14$ | $2012-11-14$ |
| U/S 90th \%tile | 45.8 |  |  |
| U/S 95th \%tile | 47.9 |  |  |


|  | DISSOLVED |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs |  |
| Mean |  |  |  |
| Geo_mean |  |  |  |
| Median |  |  |  |
| Mle_used |  |  |  |
| Dist |  |  |  |
| N_total |  |  |  |
| N_bdl |  |  |  |
| N_non_bdl |  |  |  |
| Min_detect |  |  |  |
| Max_detect |  |  |  |
| Min_date |  |  |  |
| Max_date |  |  |  |
| U/S 90th \%tile | 45.5 |  |  |
| U/S 95th \%tile | 48 |  |  |
|  |  |  |  |



















































































































































|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 314 | 314 | 314 |
| Geo_mean | 250 | 250 | 250 |
| Median | 436 | 436 | 436 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 7 | 7 | 7 |
| N_bdl | 0 | 0 | 0 |
| N_non_bdl | 7 | 7 | 7 |
| Min_detect | 89 | 89 | 89 |
| Max_detect | 484 | 484 | 484 |
| Min_date | $2013-08-06$ | $2013-08-06$ | $2013-08-06$ |
| Max_date | $2014-01-07$ | $2014-01-07$ | $2014-01-07$ |
| U/S 90th \%tile | 684 |  |  |
| U/S 95th \%tile | 910 |  |  |


|  | DISSOLVED |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 30 | 30 | 30 |
| Geo_mean | 30 | 30 | 30 |
| Median | 30 | 30 | 30 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 7 | 7 | 7 |
| N_bdl | 7 | 7 | 7 |
| N_non_bdl | 0 | 0 | 0 |
| Min_detect |  |  |  |
| Max_detect |  |  |  |
| Min_date | $2013-08-06$ | $2013-08-06$ | $2013-08-06$ |
| Max_date | $2014-01-07$ | $2014-01-07$ | $2014-01-07$ |
| U/S 90th \%tile | 30 |  |  |
| U/S 95th \%tile | 30 |  |  |








|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  | 376 |
| Geo_mean | 102 | 104 | 138 |
| Median | 102 | 104 | 89 |
| Mle_used | Y | Y | N |
| Dist | lognormal | lognormal | no_dist |
| N_total | 609 | 177 | 44 |
| N_bdl | 1 | 1 | 0 |
| N_non_bdl | 608 | 176 | 44 |
| Min_detect | 2.5 | 2.5 | 15.1 |
| Max_detect | 21000 | 4980 | 2550 |
| Min_date | $1984-08-08$ | $2004-01-26$ | $2011-01-17$ |
| Max_date | $2013-05-13$ | $2013-05-13$ | $2013-05-13$ |
| U/S 90th \%tile | 684 |  |  |
| U/S 95th \%tile | 910 |  |  |


|  | DISSOLVED |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  | 12.6 |
| Geo_mean | 4.17 | 4 | 3.82 |
| Median | 4.17 | 4 | 2 |
| Mle_used | Y | Y | N |
| Dist | lognormal | lognormal | no_dist |
| N_total | 183 | 165 | 44 |
| N_bdl | 1 | 1 | 0 |
| N_non_bdl | 182 | 164 | 44 |
| Min_detect | 0.5 | 0.5 | 0.6 |
| Max_detect | 1090 | 675 | 98.9 |
| Min_date | $2003-04-07$ | $2004-01-26$ | $2011-01-17$ |
| Max_date | $2013-05-13$ | $2013-05-13$ | $2013-05-13$ |
| U/S 90th \%tile | 30 |  |  |
| U/S 95th \%tile | 30 |  |  |















|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 50 | 50 | 50 |
| Geo_mean | 50 | 50 | 50 |
| Median | 50 | 50 | 50 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 2 | 2 | 2 |
| N_bdl | 2 | 2 | 2 |
| N_non_bdl | 0 | 0 | 0 |
| Min_detect |  |  |  |
| Max_detect |  |  |  |
| Min_date | $2012-11-14$ | $2012-11-14$ | $2012-11-14$ |
| Max_date | $2012-11-14$ | $2012-11-14$ | $2012-11-14$ |
| U/S 90th \%tile | 684 |  |  |
| U/S 95th \%tile | 910 |  |  |


|  |  | DISSOLVED |  |  |
| :--- | :--- | :---: | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |  |
| Mean |  |  |  |  |
| Geo_mean |  |  |  |  |
| Median |  |  |  |  |
| Me_used |  |  |  |  |
| Dist |  |  |  |  |
| N_total |  |  |  |  |
| N_bdl |  |  |  |  |
| N_non_bdl |  |  |  |  |
| Min_detect |  |  |  |  |
| Max_detect |  |  |  |  |
| Min_date |  |  |  |  |
| Max_date |  |  |  |  |
| U/S 90th \%tile | 30 |  |  |  |
| U/S 95th \%tile | 30 |  |  |  |
|  |  |  |  |  |





|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  |  |
| Geo_mean | 27.5 | 27.5 | 27.5 |
| Median | 27.5 | 27.5 | 27.5 |
| Mle_used | Y | Y | Y |
| Dist | lognormal | lognormal | lognormal |
| N_total | 14 | 14 | 14 |
| N_bdl | 2 | 2 | 2 |
| N_non_bdl | 12 | 12 | 12 |
| Min_detect | 10 | 10 | 10 |
| Max_detect | 70 | 70 | 70 |
| Min_date | $2013-04-16$ | $2013-04-16$ | $2013-04-16$ |
| Max_date | $2013-11-05$ | $2013-11-05$ | $2013-11-05$ |
| U/S 90th \%tile | 684 |  |  |
| U/S 95th \%tile | 910 |  |  |


|  |  | DISSOLVED |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 10 | 10 | 10 |
| Geo_mean | 10 | 10 | 10 |
| Median | 10 | 10 | 10 |
| MIe_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 14 | 14 | 14 |
| N_bdl | 14 | 14 | 14 |
| N_non_bdl | 0 | 0 | 0 |
| Min_detect |  |  |  |
| Max_detect |  |  |  |
| Min_date | $2013-04-16$ | $2013-04-16$ | $2013-04-16$ |
| Max_date | $2013-11-05$ | $2013-11-05$ | $2013-11-05$ |
| U/S 90th \%tile | 30 |  |  |
| U/S 95th \%tile | 30 |  |  |
|  |  |  |  |
|  |  |  |  |





|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  |  |
| Geo_mean | 12.3 | 12.3 | 12.3 |
| Median | 12.3 | 12.3 | 12.3 |
| Mle_used | Y | Y | Y |
| Dist | lognormal | lognormal | lognormal |
| N_total | 14 | 14 | 14 |
| N_bdl | 5 | 5 | 5 |
| N_non_bdl | 9 | 9 | 9 |
| Min_detect | 10 | 10 | 10 |
| Max_detect | 30 | 30 | 30 |
| Min_date | $2013-04-16$ | $2013-04-16$ | $2013-04-16$ |
| Max_date | $2013-11-05$ | $2013-11-05$ | $2013-11-05$ |
| U/S 90th \%tile | 684 |  |  |
| U/S 95th \%tile | 910 |  |  |


|  |  | DISSOLVED |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 10 | 10 | 10 |
| Geo_mean | 10 | 10 | 10 |
| Median | 10 | 10 | 10 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 14 | 14 | 14 |
| N_bdl | 14 | 14 | 14 |
| N_non_bdl | 0 | 0 | 0 |
| Min_detect |  |  |  |
| Max_detect |  |  |  |
| Min_date | $2013-04-16$ | $2013-04-16$ | $2013-04-16$ |
| Max_date | $2013-11-05$ | $2013-11-05$ | $2013-11-05$ |
| U/S 90th \%tile | 30 |  |  |
| U/S 95th \%tile | 30 |  |  |





























































































| $10^{4}$ | Dissolved |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | $-\quad-\quad-$ | - - | - - - | - - - |
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|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 1 |  |  | T |
|  |  |  |  |  | 09/15/2013 | 10/01/2013 | 10/15 |  | 11/01/2013 |
|  |  |  |  |  |  |  | DISS |  |  |
|  |  |  |  |  |  | Parameter | All yrs | Last 10 yrs | Last 3 yrs |
|  |  |  |  |  |  | Mean | 0.737 | 0.737 | 0.737 |
|  |  |  |  |  |  | Geo_mean | 0.732 | 0.732 | 0.732 |
|  |  |  |  |  |  | Median | 0.714 | 0.714 | 0.714 |
|  |  |  |  |  |  | Mle_used | $\mathrm{N}$ |  |  |
|  |  |  |  |  |  | Dist | no_dist | no_dist | no_dist |
|  |  |  |  |  |  | N_total | $14$ | $14$ | $14$ |
|  |  |  |  |  |  | N_bdl | 0 | 0 | 0 |
|  |  |  |  |  |  | N_non_bdl | 14 | 14 | 14 |
|  |  |  |  |  |  | Min_detect | 0.596 | 0.596 | 0.596 |
|  |  |  |  |  |  | Max_detect | 0.969 | 0.969 | 0.969 |
|  |  |  |  |  |  | Min_date | 2013-08-07 | 2013-08-07 | 2013-08-07 |
|  |  |  |  |  |  | Max_date | 2013-11-06 | 2013-11-06 | 2013-11-06 |
|  |  |  |  |  |  | U/S 90th \%tile | 0.915 |  |  |
|  |  |  |  |  |  | U/S 95th \%tile | 0.947 |  |  |
























































































































































































|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 1.05 | 1.05 | 1.05 |
| Geo_mean | 1.04 | 1.04 | 1.04 |
| Median | 1 | 1 | 1 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 14 | 14 | 14 |
| N_bdl | 0 | 0 | 0 |
| N_non_bdl | 14 | 14 | 14 |
| Min_detect | 0.7 | 0.7 | 0.7 |
| Max_detect | 1.4 | 1.4 | 1.4 |
| Min_date | $2013-04-16$ | $2013-04-16$ | $2013-04-16$ |
| Max_date | $2013-11-05$ | $2013-11-05$ | $2013-11-05$ |
| U/S 90th \%tile | 0.135 |  |  |
| U/S 95th \%tile | 0.143 |  |  |


|  | DISSOLVED |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  |  |
| Geo_mean | 0.956 | 0.956 | 0.956 |
| Median | 0.956 | 0.956 | 0.956 |
| Mle_used | $Y$ | $Y$ | Y |
| Dist | lognormal | lognormal | lognormal |
| N_total | 14 | 14 | 14 |
| N_bdl | 1 | 1 | 1 |
| N_non_bdl | 13 | 13 | 13 |
| Min_detect | 0.7 | 0.7 | 0.7 |
| Max_detect | 1.6 | 1.6 | 1.6 |
| Min_date | $2013-04-16$ | $2013-04-16$ | $2013-04-16$ |
| Max_date | $2013-11-05$ | $2013-11-05$ | $2013-11-05$ |
| U/S 90th \%tile | 0.14 |  |  |
| U/S 95th \%tile | 0.164 |  |  |





|  | TOTAL |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean | 1.09 | 1.09 | 1.09 |
| Geo_mean | 1.07 | 1.07 | 1.07 |
| Median | 1.1 | 1.1 | 1.1 |
| Mle_used | N | N | N |
| Dist | no_dist | no_dist | no_dist |
| N_total | 14 | 14 | 14 |
| N_bdl | 0 | 0 | 0 |
| N_non_bdl | 14 | 14 | 14 |
| Min_detect | 0.8 | 0.8 | 0.8 |
| Max_detect | 1.3 | 1.3 | 1.3 |
| Min_date | $2013-04-16$ | $2013-04-16$ | $2013-04-16$ |
| Max_date | $2013-11-05$ | $2013-11-05$ | $2013-11-05$ |
| U/S 90th \%tile | 0.135 |  |  |
| U/S 95th \%tile | 0.143 |  |  |


|  | DISSOLVED |  |  |
| :--- | :--- | :--- | :--- |
| Parameter | All yrs | Last 10 yrs | Last 3 yrs |
| Mean |  |  |  |
| Geo_mean | 0.971 | 0.971 | 0.971 |
| Median | 0.971 | 0.971 | 0.971 |
| Mle_used | $Y$ | Y | Y |
| Dist | lognormal | lognormal | lognormal |
| N_total | 14 | 14 | 14 |
| N_bdl | 1 | 1 | 1 |
| N_non_bdl | 13 | 13 | 13 |
| Min_detect | 0.7 | 0.7 | 0.7 |
| Max_detect | 1.4 | 1.4 | 1.4 |
| Min_date | $2013-04-16$ | $2013-04-16$ | $2013-04-16$ |
| Max_date | $2013-11-05$ | $2013-11-05$ | $2013-11-05$ |
| U/S 90th \%tile | 0.14 |  |  |
| U/S 95th \%tile | 0.164 |  |  |




















| $\begin{aligned} & 10^{3} \\ & 10^{2} \end{aligned}$ | Dissolved |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | E |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| $10^{-2}$ | E- |  |  |  |  |  |  |  |  |
| $10^{-3}$ |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | 1 | 1 |  |  | 1 |
|  | 08/15/2013 |  | 09/01/2013 |  | 09/15/2013 | 10/01/2013 | 10/15/2013 |  | 11/01/2013 |
|  | TOTAL |  |  |  |  | DISSOLVED |  |  |  |
|  | Parameter | All yrs | Last 10 yrs |  |  | Parameter | All yrs | Last 10 yrs | Last 3 yrs |
|  | Mean | 0.0106 | $0.0106$ | $0.0106$ |  | Mean | $0.01$ | $0.01$ | $0.01$ |
|  | Geo_mean | 0.0105 | 0.0105 | 0.0105 |  | Geo_mean | 0.01 | 0.01 | 0.01 |
|  | Median | 0.01 | 0.01 | 0.01 |  | Median | 0.01 | 0.01 | 0.01 |
|  | Mle_used | N | N | N |  | Mle_used | N | N | N |
|  | Dist | no_dist | no_dist | no_dist |  | Dist | no_dist | no_dist | no_dist |
|  | N_total | $13$ | $13$ | 13 |  | N_total | $13$ | $13$ | 13 |
|  | N_bdl | $12$ | $12$ | 12 |  | N_bdl | $13$ | $13$ | 13 |
|  | N_non_bdl | 1 | 1 | 1 |  | N_non_bdl | 0 | 0 | 0 |
|  | Min_detect | 0.018 | 0.018 | 0.018 |  | Min_detect |  |  |  |
|  | Max_detect | 0.018 | 0.018 | 0.018 |  | Max_detect |  |  |  |
|  | Min_date | 2013-08-07 | 2013-08-07 | 2013-08-07 |  | Min_date | 2013-08-07 | 2013-08-07 | 2013-08-07 |
|  | Max_date | 2013-11-06 | 2013-11-06 | 2013-11-06 |  | Max_date | 2013-11-06 | 2013-11-06 | 2013-11-06 |
|  | U/S 90th \%tile | $0.0118$ |  |  |  | U/S 90th \%tile | $0.01$ |  |  |
|  | U/S 95th \%tile | $0.0122$ |  |  |  | U/S 95th \%tile | 0.01 |  |  |


































































| $\begin{aligned} & 10^{3} \\ & 10^{2} \end{aligned}$ | Dissolved |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 08/15/2013 |  | 09/01/2013 |  | -1 | 10/01/2013 | 10/15/2013 |  | 11/01/2013 |  |
|  | TOTAL |  |  |  |  | DISSOLVED |  |  |  |  |
|  | Parameter | All yrs | Last 10 yrs | Last 3 yrs |  | Parameter | All yrs | Last 10 yrs | Last 3 yrs |  |
|  | Mean | 142 | 142 | 142 |  | Mean | 135 | 135 | 135 |  |
|  | Geo_mean | 142 | 142 | 142 |  | Geo_mean | 134 | 134 | 134 |  |
|  | Median | 144 | 144 | 144 |  | Median | 136 | 136 | 136 |  |
|  | Mle_used | N | N | N |  | Mle_used | N | N | N |  |
|  | Dist | no_dist | no_dist | no_dist |  | Dist | no_dist | no_dist | no_dist |  |
|  | N_total | $14$ | $14$ |  |  | N_total |  | 14 |  |  |
|  | N_bdl | 0 | 0 | 0 |  | N_bdl | 0 | 0 | 0 |  |
|  | N_non_bdl | 14 | 14 | 14 |  | N_non_bdl | 14 | 14 | 14 |  |
|  | Min_detect | 123 | 123 | 123 |  | Min_detect | 115 | 115 | 115 |  |
|  | Max_detect | 162 | 162 | 162 |  | Max_detect | 151 | 151 | 151 |  |
|  | Min_date | 2013-08-07 | 2013-08-07 | 2013-08-07 |  | Min_date | 2013-08-07 | 2013-08-07 | 2013-08-07 |  |
|  | Max_date | 2013-11-06 | 2013-11-06 | 2013-11-06 |  | Max_date | 2013-11-06 | 2013-11-06 | 2013-11-06 |  |
|  | U/S 90th \%tile | 197 |  |  |  | U/S 90th \%tile | $190$ |  |  |  |
|  | U/S 95th \%tile | 209 |  |  |  | U/S 95th \%tile | 202 |  |  |  |



























































































































































































































[^0]:    ${ }^{1}$ The USEPA recommended draft selenium criteria of $8.1 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ for whole body and $11.8 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ for muscle, but the whole body selenium criterion of $8.1 \mathrm{mg} / \mathrm{kg} \mathrm{dw}$ was conservatively applied to muscle selenium data for simplicity.
    ${ }^{2}$ A description of non-mine influenced area samples is available in the draft 2014 Aquatic Environment Synthesis Report, with a significant portion of the non-mine influenced data being collected within the Transboundary Flathead River Drainage (e.g., Flathead Lake, upper Flathead River, and Wigwam River drainages).
    ${ }^{3}$ Burbot data were excluded due to uncertainties associated with moisture content and desiccation, while mountain whitefish data were excluded because this species tends to have relatively high selenium concentrations regardless of capture location (exposed or non-mine influenced areas).

[^1]:    ${ }^{4}$ http://www.env.gov.bc.ca/wat/wq/BCguidelines/mercury/mercury.html\#tab5.

